1.0 URANIUM MASS BALANCE PROJECT

1.1 Project Overview

The Recycled Uranium Project at the Rocky Flats Environmental Technology Site (Site) was conducted in accordance with the *DOE Project Plan for Historical Generation and Flow of Recycled Uranium in the DOE Complex,* dated February 2000. Following a formal request from DOE, RFFO[1], a cost estimate and plan was prepared and submitted by Kaiser-Hill Company, LLC[2]. DOE, RFFO directed the project to be performed[3] and a Baseline Change Proposal was submitted[4] and approved in January 2000. The Site plan was established to address both the near-term and long-term questions in the DOE National Project Plan. A significant portion of the plan was completed by March and a draft report issued that was based on the data available at that time. In late April the site obtained copies of reports from the source sites for a significant amount of the DU shipped to the Site. The final report was revised based on source site mass balance information, some additional worker exposure numbers, and environmental release data.

1.2 Purpose and Scope

The purpose of the Site plan was to prepare a report in the outline of the DOE Project Plan based on the information available at the Site. The questions in the DOE Plan have the overall objective of meeting the goals established in the T.J. Glauthier, Memoradum of September 15, 1999. These goals are to:

- Identify the mass flow of DOE recycled uranium from early production to mid-1999, including ultimate use and disposition. Create an unclassified inter-site flow sheet for public availability.
- Identify the characteristics and contaminants in the major uranium streams, specifically, the technetium, neptunium, plutonium, or other isotopic content of concern to worker or public health and safety.
- Conduct site mass balance activities sufficiently thorough to identity any significant implications for potential personnel exposure or environmental contamination.

Since the Site has transitioned to the Decommissioning and Demolition (D&D) stage, most of the historical processing records have been sent to Los Alamos National Laboratory (LANL). The scope did not include researching off-site process records or specific Site personnel exposure records. A data search was made to determine the number of bio-assays and external dosimetry badges of workers who were monitored over the Site's history. The number of workers who have been monitored since 1953 is estimated to be in the thousands.

Uranium processing started at the Site in 1953 and continued through 1989. The machining of DU products continued through 1993. Significant quantities of both HEU and DU were processed during this time frame. Therefore, the scope of the data search covers these time frames for both forms of uranium. The Site also processed some natural uranium and uranium-233, which are not included in this scope. By definition, the natural uranium would not be considered reactor recycle material. Uranium-233 was not included by DOE direction because of the radiation exposure to workers due to any trace transuranics would not be a significant contribution to their total exposure. The workers involved in the U-233 processing were monitored very carefully during the time of processing. Highly enriched uranium was also used in criticality experiments with metals, oxides, and in a nitrate solution conducted in Building 886. The criticality experiments are not related to the issues addressed in this report.

1.3 Project Implementation

The Site project was implemented through two parallel activities. The objective of the first activity was to establish mass balance data on uranium materials received and shipped. Mass balance data were generated separately for HEU and DU. The data source for this effort was the inventory transaction records (receipts and shipments) covering the period of 1953 to the present. A subcontractor was contracted to research the data starting in 1953 through completion of operations. The search was conducted in a classified area using the paper records of receipts and shipments from 1952 until about 1969. After 1970, the accountability data was put into a computer system and this system was used to obtain the remaining information. During the period that the records were searched, the Site processed significant quantities of highly enriched uranium and 8,029 metric tons of DU. The compilations of inventory transactions for DU are provided in Appendix A and summarized in Appendix B to this report. The same shipper-receiver information for HEU is classified and the data base is not includes in this report.

The second activity was to establish a group of "old timers" associated with the processing of both highly enriched and depleted uranium. A contract was established to bring back retirees that had process knowledge and supplement this group with some long-term personnel who were still on the Site with other assignments[6]. The specific assignment was for this group to identify major processing operations and then to evaluate the processes that could have resulted in the concentration of transuranics or releases into the systems within the buildings.

The results of this activity determined that of all the processes considered only two had the potential for accumulation or release of the trace transuranics or fission products. The first process was melting to form ingots or castings in Building 444. The vacuum melting furnaces were bottom pour which left the impurities on the top of the melt called a skull or dross. Consequently, some concentration may have occurred in the skull. The second process, a chip roasting operation to oxidize scrap materials (which consisted of machine turnings/chips and the dross from the melting operation) had the potential to release material to the building environment. Smaller pieces of skull were put into the chip roaster with other depleted uranium materials and roasted. Larger sections were oxidized separately in a burnout hood. The supporting details of this summary are provided later in this report.

The two activities were integrated through a series of meetings with all the participants to share information and questions. One key question, for which external information was required, pertained to the quantity of transuranic constituents in the uranium materials processed on the Site. The specifications for uranium products focused on total elemental impurities and on alloying elements. The analyses of transuranics or fission products were not a requirement and were not performed. The analytical constituents of transuranics and fission products in the source materials are based on data provided by the source sites, such as, FEMP and Paducah.

The final activity combined all the available information into a final report applicable to the DOE report *de minimis* outline.

2.0 SITE HISTORICAL OVERVIEW

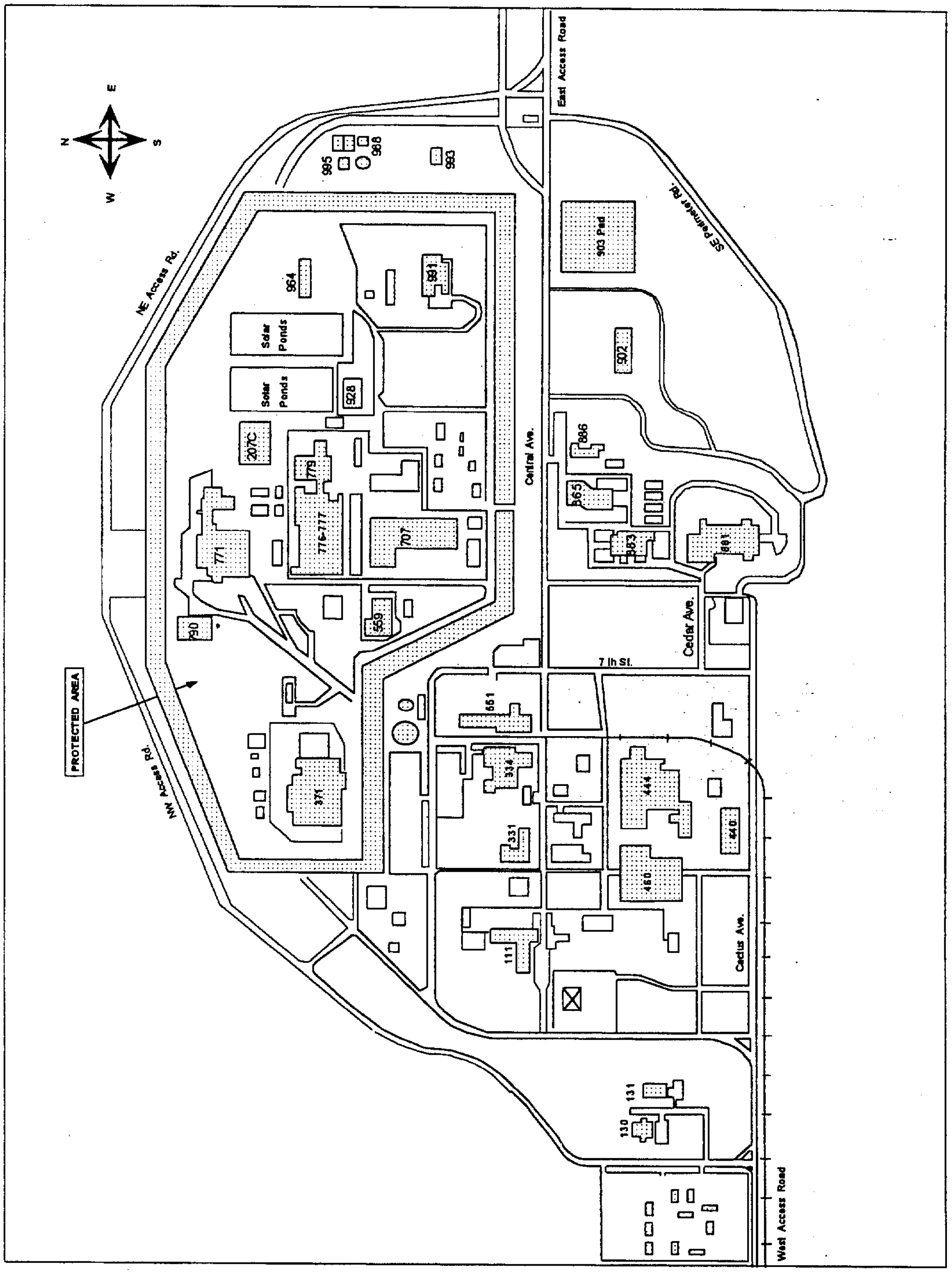
2.1 Site Description

The Rocky Flats Environmental Technology Site (Site) is located about 15 miles northwest of downtown Denver, Colorado, and is now designated as an environmental cleanup site. The Site is similar to a small city. It is comprised of more than 700 structures located on a 385-acre Industrial Area surrounded by nearly 6,000 acres of controlled open space. The open space serves as a buffer between the Site and adjacent communities. From 1953 to 1989, the primary mission of Rocky Flats was the production of nuclear and non-nuclear weapons components for the Nation's nuclear arsenal. The key production component was the plutonium pit, commonly referred to as the "trigger," which provides energy to fuel the explosion of a thermonuclear weapon.

The Site also used the production capabilities to process uranium, both HEU and DU, for thermonuclear weapon components and products for other agencies. The uranium processing and production is the subject of interest to this report. Within the Industrial Area (Figure 1), the Site was historically divided between the North Side being devoted to plutonium processing and production and the South Side to uranium and non- nuclear production.

In 1993 the Site's production mission responsibilities were terminated and transferred to other DOE facilities. The new Site mission became one of deactivating the production facilities and proceeding with decommissioning , demolition and environmental restoration.

Figure 1.



Central Portion of the Rocky Flats Environmental Technology Site

2.2 Key Uranium Processing Facilities

- **Highly enriched uranium production**

Highly enriched uranium started in 1953 in Building 881. HEU was obtained from Oak Ridge and processed in Building 881. Final machining of components was performed in Building 881 and then made available for assembly into the deliverable product. In 1965, the Site's mission responsibility for producing HEU components was transferred to the Y12 Plant. The overview flow of HEU on the Site is shown on Figure 2[7]. Limited operations, associated with shutdown and cleanup, of residual HEU continued through 1967. The time periods for HEU War Reserve (WR) Mission and Special Projects are listed in Table 1.

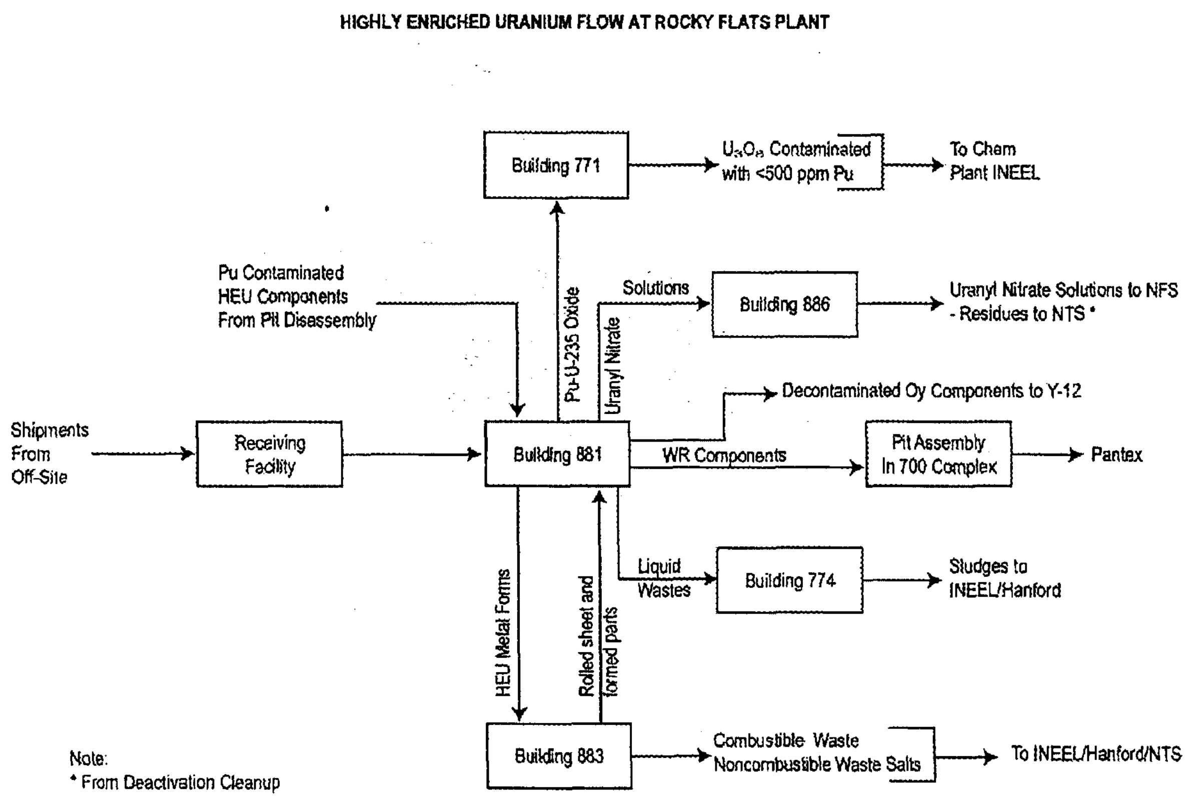


Figure 2.

TABLE 1.
HIGHLY ENRICHED URANIUM MISSION AND SPECIAL PROJECTS

Mission/ Projects	Start	End	Years Duration	Materials	Buildings	Processes	Customer
	Time Line						
War Reserve (HEU) Component Fabrication	1953	1964	11	Metal	881, 883	Melting, casting, rolling, forming, trimming, machining, heat treatment, cleaning, and inspection.	AEC/ DOE
HEU Chemical Recovery & Recycle	1953	1966	13	Nitrate Solutions	881	Dissolution, filtration, precipitation,	AEC/ DOE

Chemical decontamination processing of HEU components derived from pit disassembly operations was initially performed in one room of Building 881 and then later transferred to Building 771. The process was continued in Building 771 until 1989. This process removed plutonium contamination via a nitric acid water wash leach cycle. The decontaminated parts were then returned to the Y12 Plant. In 1997, an electrolytic decontamination process was installed in Building 707 to remove plutonium contamination from legacy HEU parts that remained on the Site when weapon production was terminated. The decontaminated parts from this process were also shipped to the Y12 Plant. This operation was completed in 1999. Decontamination of plutonium was determined by surface smears over the entire period and would not detect any plutonium that penetrated the uranium surface. It is possible that trace quantities of Pu may have been present in the HEU returned to Y-12.

- **Depleted uranium production**

The major depleted uranium (DU) processing and production occurred in Buildings 444, 865, 883, with some related activities in structures attached to these buildings that have individual numbers. Figure 3[7] illustrates the overall flow of depleted uranium at the Site. The time periods for the War Reserve (WR) Mission and Special Projects are listed in Table 2[7]. Over the years, Building 444 supported the WR and special order programs at the Site. Processes included melting for casting, machining, welding, brazing, etching, coating or plating, heat treating, cleaning, leak and pressure testing, and final inspection. Various metals including depleted and alloys of depleted uranium were processed in Building 444. The process in Building 444 of interest in this report is the melting operations for alloy formation, scrap consolidation, and castings.

Building 447, an attached structure to Building 444 was used for some manufacturing processes and a waste handling facility. One of the waste operations of interest to this report was processing of depleted uranium chips, turnings, and other scrap from Buildings 444, 865, and 883. These were cleaned, oxidized, and shipped off Site for disposal or recovery. The oxidation process was performed in a "chip roaster" to reduce a large part of the metal to an oxide state for fire safety reasons and to satisfy storage and shipping requirements. The processing operations in Buildings 865 and 883 consisted of rolling, shearing, blanking/trepanning, forming, and cleaning of various metals including depleted and alloys of depleted uranium. Preheating of the uranium was also included for some operations but the temperatures were not sufficient to change the composition of the material.

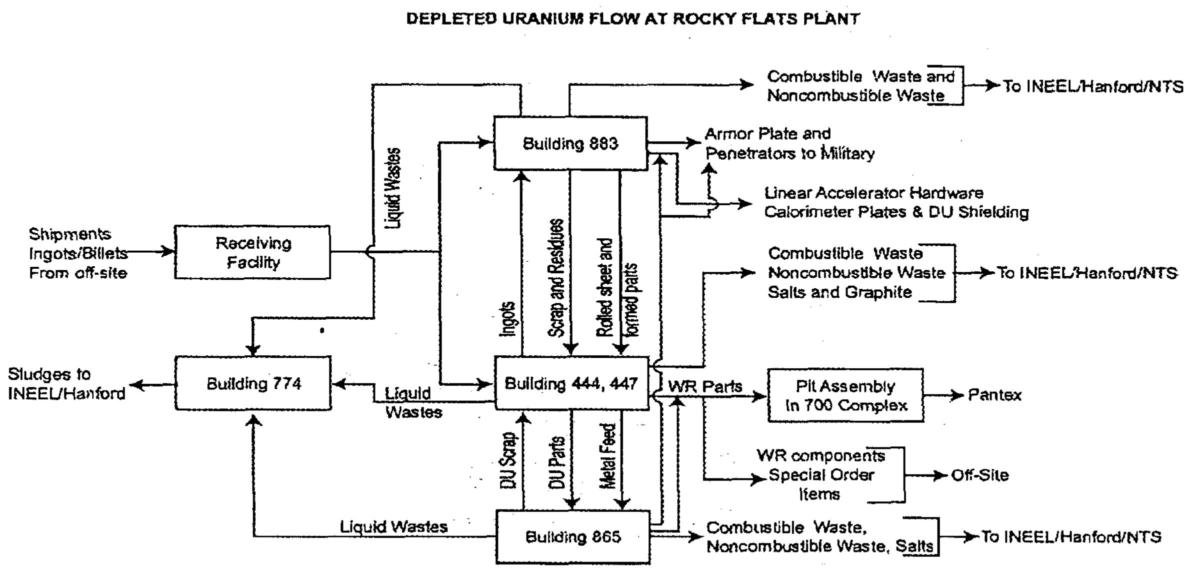


Figure 3.

TABLE 2.

DEPLETED URANIUM MISSION AND SPECIAL PROJECTS

Mission/Project	Start	End	Years Duration	Materials	Buildings	Processes	Customer
War Reserve Production	1953	1989	36	DU and DU Alloys	444, 447, 865, 883	Casting, rolling, forming, shearing, heat treating, machining, inspection, testing, and cleaning	DOE
Master Alloy for Pu/U/Mo ZPPR Fuel Plates	1967	1969	2	DU/Mo	444	Casting and cleaning.	ANL
Armor Plate Fabrication R&D and Production	1979	1988	9	DU and DU Alloys	865, 883	Casting, rolling, forming, Shearing, and cleaning.	DOD
Penetrator R&D and Production	1980	1984	2	DU and DU Alloys	444, 865	Casting, extruding, machining, testing and inspection	DOD
Linear Accelerator Shielding and Calorimeter Plate Fabrication	1977	1984	7	DU	883	Casting, rolling, forming, shearing, and cleaning.	CERN

- **Personnel Monitoring**

The Site measured personnel radiation exposure from the start of production in 1953. Exposure records are available on the Site but were not searched as part of this project. In addition, urine bioassay samples were analyzed for the workers and the records are also available. The methods to measure radiation exposure and the analytical processes used for bioassay changed over the years with improvements in measuring technology. In 1964, the use of lung counting for plutonium was introduced on the Site. The lung counter also had the capacity for measuring uranium in the lungs. It was used periodically for uranium measurements from the 1960s' through the 1990s'. Worker monitoring also included organ function tests that were conducted as part of routine physical examinations. The tests were to monitor any abnormal functions caused by exposure to toxic agents such as uranium. Sampling of the work and processing areas for airborne uranium was conducted over the entire production period in all uranium facilities.

- **Environmental Monitoring**

Environmental radiological release data have been collected from the start of production. The data includes the total radionuclide emissions from the Site for plutonium-238, plutonium-239, americium-241, uranium-233, uranium-234, uranium-235, uranium-238, and tritium (H-3). Data were obtained from the individual facility stack monitors and Site boundary monitors. Since 1953, these data have been reported monthly and summarized in Annual Environmental Monitoring Reports starting in 1972. A report prepared for the Colorado Department of Public Health and Environment (CDPH&E) in March 1994 covers the historical emissions from 1952 to 1989. The release to the environment has always been very small. Samples that have been collected downstream for environmental analysis have always been near the lowest detection limits of the analysis because the nuclear facilities have always had high efficiency multi-filters in the exhaust of the ventilation systems . Any contribution to the environmental releases due to trace transuranics, especially plutonium, or fission products would have been included in these data.

2.2.1 Building 881

2.2.1.1 Plant Description

Building 881 was the original process building on the Site for highly enriched uranium[8]. The building is a reinforced concrete structure, built mostly below grade and is located on the southeast side of the Site. The northwest corner of the second floor of Building 881 is connected by a tunnel to the southwest basement corner of Building 883. The tunnel was originally used to convey enriched uranium parts between the two buildings. An annex was added to the north side of the building in 1957. There is a total of about 245,000 square feet in the structure located on four floors and two mezzanines. Most of the production operations occurred on the second floor.

In 1965, all of the highly enriched uranium manufacturing activities were transferred to the Y12 plant and, in 1967, the WR production was converted to non-radioactive metals. These were primarily stainless steel components. Some radioactive operations with special materials for other applications and R&D projects were performed in this building after 1967.

2.2.1.2 Process Flow

The Building 881 HEU Recovery and Recycle Process Flow are shown on Figure 4. The EU Fabrication Process for Buildings 881 and 883 are shown in Figure 5.

2.2.1.3 Feed Specifications

The feed specifications pertained to the metal materials received from the Y-12 Plant. These specifications were focused on chemical purity and isotopic content. No requirements existed for transuranic analyses and none were performed.

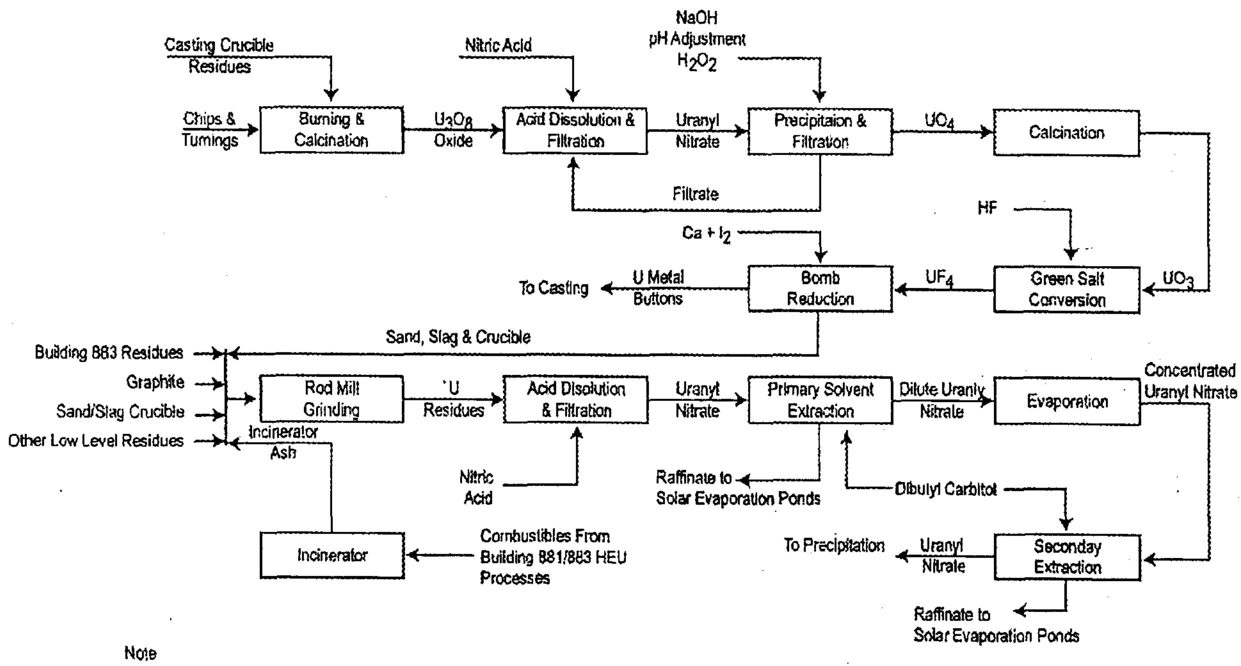
2.2.1.4 Product Specifications

The material specifications for the finished EU metal products produced in Building 881 were similar to those for the metal materials and pertained to chemical purity and isotopic content. These specifications are classified. Analyses for transuranics were not performed.

2.2.1.5 Operating History

The EU processes in Building 881 included foundry (casting) operations, machining, assembly, testing, and final inspection and chemical processing facilities for recovering EU metal from process residues. In 1965, the U.S. adopted a single mission policy and all of the EU manufacturing activities were consolidated at the Y12 plant and the Site EU operations were terminated. Approximately one year later, in 1966, the mission work for producing stainless steel boost reservoirs was transferred to the Site from the American Car and Foundry facility in Albuquerque. Building 881 was designated as the Site location for this new mission work and the EU processing facility was transformed to a facility dedicated to the production of boost reservoirs and related products. Closeout of EU operations and processes was completed in 1967.

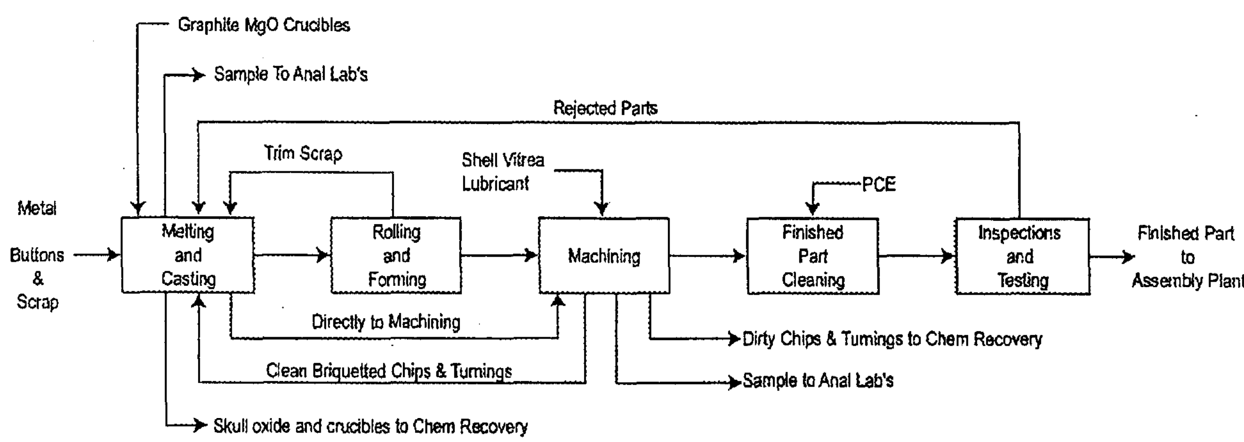
HIGHLY ENRICHED URANIUM RECOVERY AND RECYCLE PROCESS FLOW BUILDING 881



Note
- Process off-gases went to caustic scrubbing and HEPA filtration sytems
- Combustibles went to incinerator
- Materials too low in U-235 to recover were packaged for shipment off-site to INEEL and Hanford.

Figure 4.

HIGHLY ENRICHED URANIUM FABRICATION PROCESS - BUILDINGS 881 & 883



Note
- Combustible wastes went to incineration.
- Process off-gases went to caustic scrubbing and HEPA filtration systems.
- Spent lathe coolant was collected in drums and shipped to Building 774 for solidification and/or went to the burning pits based upon uranium concentration level.
- Spent cleaning (degreasing) solutions were drummed and stored and or shipped to Building 774 for solidifications.
- Rolling and forming were carried out in Building 883 Side B.
- Materials too low in U-235 to recover were packaged for shipment off-site to INEEL & Hanford.
- PCE (perchloroethylene)

Figure 5.

2.2.1.6 Production Operations

The following is a listing of the processes and operations performed in Building 881 from 1953 to 1966 with HEU materials.

- Production Operations
  - Melting and Casting
  - Rolling and Forming
  - Machining
  - Non-Destructive Testing
  - Dimensional Inspection

- Chemical Recovery and Recycle

  - Fast Cycle
    - Nitric Acid Dissolution/Filtration
    - Precipitation/Filtration/Calcination
    - Hydrofluorination
  - Metal Reduction/Button Breakout

  - Slow Recovery
    - Nitric Acid Leaching/Filtration
    - Solvent Extraction
    - Evaporation/Concentration
    - Recovered Uranyl Nitrate to Fast Recycle

  - Incineration
    - Combustible Feed
    - Ash to Slow Recovery

- Feed Materials
  - High Purity Metal Buttons from Y-12
  - High Purity Metal Buttons from Chemical Recycle (Bldg 881)

- Products
  - WR and Special Order Weapon Components
  - Pu-Contaminated U_3O_8
  - Decontaminated HEU Components (to Y-12)

- Waste Material
  - EU Contaminated Solutions to Building 774 Waste Treatment Plant
  - Solid wastes contaminated with trace amounts of HEU to off-site disposal facilities at INEEL, Idaho and Hanford, WA; On-site burial (Mound) but later retrieved and sent to INEEL

2.2.1.6 Current Status

Building 881 is currently in a shutdown mode, being prepared for D&D. Office space in the building is being used by various administrative groups. Maintenance activities are limited to maintaining the required building systems such as heat and ventilation.

2.2.2 Building 883

2.2.2.1 Plant Description

Building 883 is a two-story, steel-framed building located to the north of Building 881. The primary production that started in 1957 was the formation of metal shapes in two parallel uranium fabrication operations. The principal production was formed parts that were supplied primarily to Buildings 444 and 881 for machining. The operations involved the use of presses, rolling mills, salt baths, and annealing furnaces. The initial operations were divided into two sides of the building. Side A was used for depleted uranium production and Side B for highly enriched uranium production. Later , a Side C was added to process large quantities of depleted uranium. Highly enriched uranium production was discontinued in 1965 and the depleted uranium production was discontinued in the late 1980'.

2.2.2.2 Process Flow

The fabrication process flow for Building 883 is shown in Figure 6.

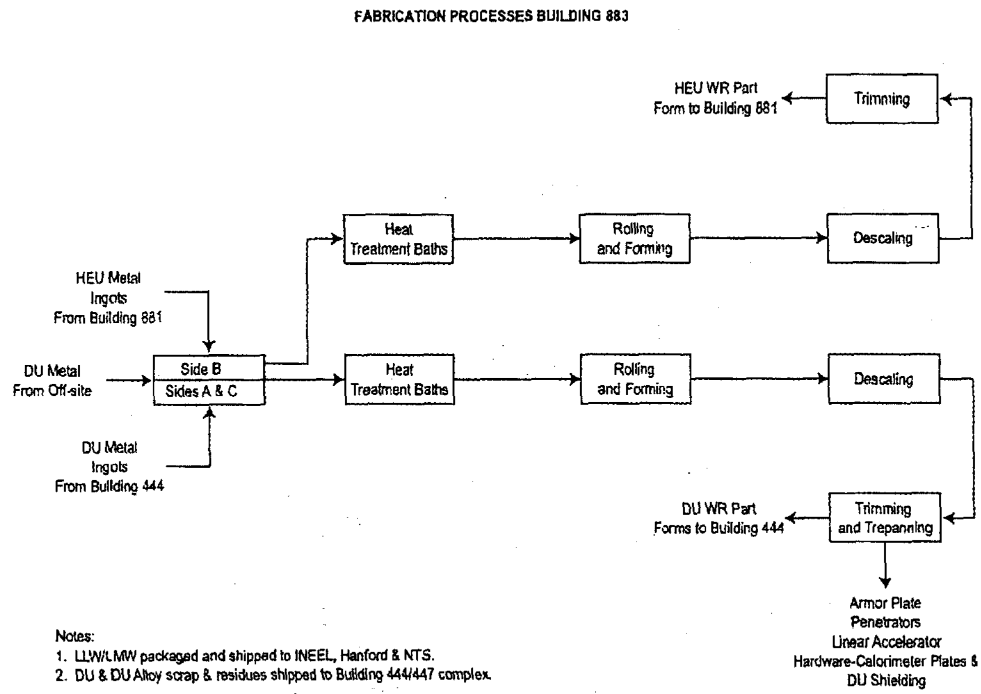


Figure 6

2.2.2.6 Production Operations

The following is a listing of the processes and operations performed in Building 883 from 1957 to 1989 with DU and HEU materials.

- <u>Production Areas</u>
  - Side A - Depleted Uranium and Other Metals (Aluminum, Stainless Steel, etc.)
  - Side B - Highly Enriched Uranium
  - Side C - Depleted Uranium (1983 thru 1989)

- <u>Production Operations</u>
  - Heat Treating
  - Rolling, and Forming
  - Shearing
  - Blanking, Trepanning
  - Cleaning
    - -- Nitric Acid Pickling
    - -- Degreasing
    - -- Grit Blasting

- <u>Feed Materials</u>
  - DU and DU Alloy Materials from Buildings 444 and/or 865
  - DU from Off-Site for Armor/Penetrator Fabrication

- DU for CERN Linerar Accelerator Hardware Fabrication
- DU for Special Order Projects

- Products
  - Rolled Sheet
  - Formed HEU and DU Parts
  - DU Armor Plate and Penetrators
  - DU Calorimeter Plates and Shielding

- Waste Material
  - Nitric Acid Cleaning Solutions
  - Other Aqueous Based Cleaning Solutions
  - Low Level Waste
    - -- Paper, Wipes, Rags, etc.
    - -- Spent Perchloroethylene, Trichloroethylene, and Trichloroethane, Freon

2.2.1.3 Feed Specifications

The feed specifications pertained to the metal materials received from the supplier facilities.

2.2.1.4 Product Specifications

The specifications for the products generated by Building 883 pertained to the mechanical property characteristics produced by the metal working operations. There were no specifications concerning chemistry, i.e., transuranic constituents.

2.2.2.5 Operating History

Building 883 began processing of both EU and DU materials in 1957. EU operations were terminated in 1965. Operations involving DU continued through 1992. This building was successfully decontaminated by a contractor for the National Conversion Pilot Project (NCCP); the decontamination process was completed in 1995. The NCCP was a DOE initiative intended to demonstrate that former nuclear weapon manufacturing facilities could be converted to commercial endeavors. The NCCP program was cancelled in 1996 because of funding limitations.

2.2.2.6 Current Status

The building is in a shutdown mode, awaiting the start of D&D operations.

2.2.3 Building 444

2.2.3.1 Plant Description

Building 444 was one of the first buildings constructed on the Site and operations involving DU began in mid-1953. The building is a reinforced concrete structure with the eastern portion having a partial basement, main floor, and mezzanine; the western portion has only a main floor. This building contained a wide range of manufacturing, testing, and inspection equipment and facilities. Among the equipment and facilities were vacuum induction casting furnaces, vacuum arc melting furnace, vacuum heat treating furnaces, a full range of machine tools, cleaning facilities, grit blasting equipment, a tooling fabrication ship, a plating laboratory, welding equipment, coating equipment, a metrology laboratory, non-destructive testing, and extensive dimensional inspection equipment. A variety of metals and materials were used in the manufacturing processes including, depleted uranium, beryllium, aluminum, stainless steel, vanadium, copper, magnesium, nickel, gold, silver, and plastics.

2.2.3.2 Process Flow

The DU fabrication process flow for Building 444 is shown in Figure 7.

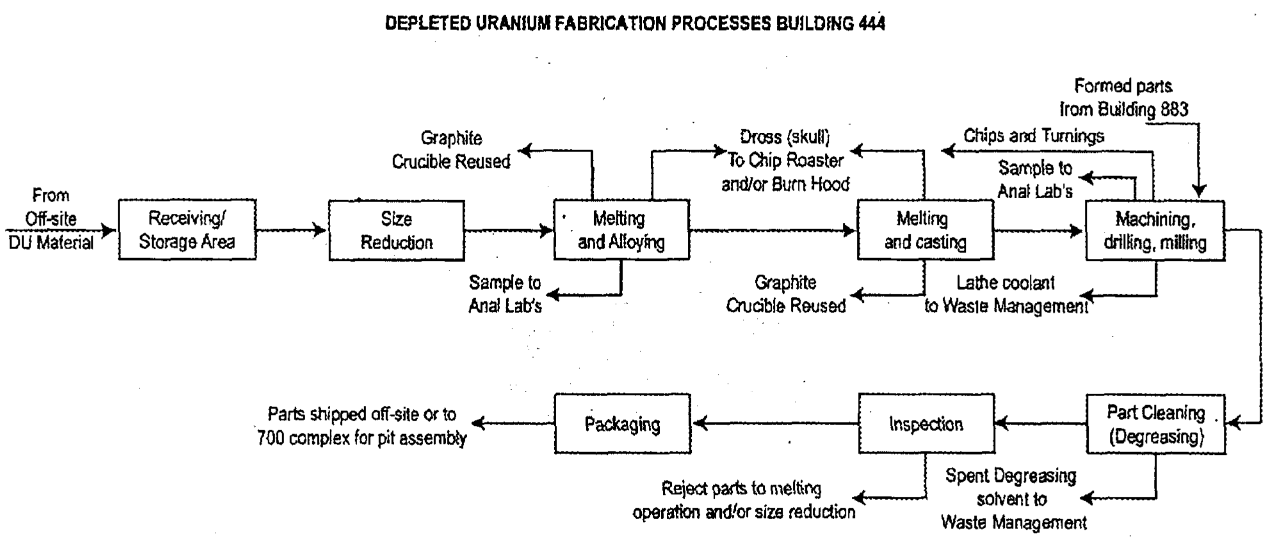


Figure 7.

2.2.3.3 Production Operations

The following is a listing of the processes, operations, and feed materials over the period from 1953 to 1994 pertaining to Building 444. Also included is a listing of the waste generated by Building 444.

- <u>Production Operations</u>
  - Melting and Casting
  - Heat Treating
  - Machining Operations (turning, milling, drilling, etc.)
  - Welding (electron-beam, tungsten-inert-gas, etc.)
  - Coating and Plating (hot-hollow-cathode, vapor deposition, chemical plating, etc.)
  - Non-Destructive Testing (radiography, density, ultrasonic, etc.)

- Dimensional Inspection (coordinate measuring machines, contour gages, optical comparators, etc.)

- Feed Materials
  - Virgin DU from Off-Site Suppliers
  - Formed Parts from Building 883
  - Recycled Scrap (including defective parts)

- Products
  - DU and DU Alloy Parts for WR Applications
  - DU and DU Alloy Parts for Special Projects

- Waste Material
  - Roaster Oxides
  - Spent Machine Lubricants, Contaminated with DU
  - Machine Filters
  - Spent Graphite Molds and Crucibles
  - Spent Cleaning Solutions
  - Miscellaneous Low Level Contaminated Materials (paper, wipes, rags, floor sweepings, etc.)

2.2.3.3 Feed Specifications

The specifications applicable to the DU materials received in Building 444 concerned purity and mechanical properties. There were no requirements pertaining to transuranic constituents and none were performed

2.2.3.4 Product Specifications

Specifications applicable to Building 444 products were final product specifications. These specifications generally concerned purity and mechanical property characteristics. There were no requirements pertaining to transuranic constituents and none were performed

2.2.3.5 Operating History

Building 444 began processing of DU materials in 1953 and continued through 1993. At that time, the production activities were terminated and the building began the transition to shutdown and eventual D&D. During this transition, the building also began disposing of excess DU materials. By September 30, 1996, approximately 120 of the Site's inventory of 263 metric tons of depleted uranium metal material had been transferred to appropriate receiver sites, primarily the Los Alamos and Lawrence Livermore National Laboratories and the Y-12 Plant.

2.2.3.6 Current Status

Building 444 currently remains in a shutdown mode, awaiting the start of D&D activities. The DU materials remaining in the building are planned for disposal as low level waste.

2.2.3.7 Potential Concentration of Transuranics

The metal working, assembly, cleaning, inspection and testing processes do not alter the basic composition of the uranium material being worked. The melting and casting processes to concentrate the imputities in the uranium melt in the dross (skull) which forms on the top of the melt. Processing experience has shown that the major portion of the dross remains behind in the graphite crucible. The dross was removed from the inside surface of the crucible by abrasive action. The collected dross was transferred to the chip roaster or to a burn hood to be oxidized form for disposal. Shipments of the oxide were made to INEEL and Hanford.

The interest in the melting and casting operation was that the dross or skull that formed on the top of the casting contained impurities but also was more radioactive than the casting. The higher radioactivity could have been due to the separation of the higher daughter products of Thorium and Protactinium and/or some concentration of trace transuranics. In some cases, the top inch of the casting was cut off and recycled into future melts. At some point, the dross or skull was sent to the roaster for oxidation in the burn out hood. While there is no chemical analysis available to verify that some accumulation of transuranics could occur in this process, there is reason to believe that lower weight oxides which may include some transuranics which would float to the top during the melting cycle. Any release from the melt would have been into the furnace vacuum system consisting of roughing and diffusion pumps. The working group did not recall if the vacuum systems exhibited any higher than expected radiation levels during maintenance. However, some members did recall that in the early days there was carry over of uranium particles into the roughing pumps that caused some reactions with water contained in the oil. These reactions were eliminated by frequently changing the oil.

2.2.4 Building 447

2.2.4.1 Building Description

Building 447 is connected to the southwest corner of Building 444[12]. It is a one story steel structure with a mezzanine and a partial basement. The mezzanine is a partial second floor. Operations in the building started in 1956 and ceased in 1994. The building was a multi-purpose manufacturing and waste processing facility. Products were welded, machined, pressure and leak checked, cleaned, assembled, packaged, and shipped from this facility. Depleted uranium chips and residues from other buildings were sent to this facility where they were cleaned, oxidized (processed in the chip roaster), packaged and shipped off Site for disposal.

2.2.4.2 Process Flow

The DU waste processing operations are shown in Figure 8; the production operations are shown in Figure 9.

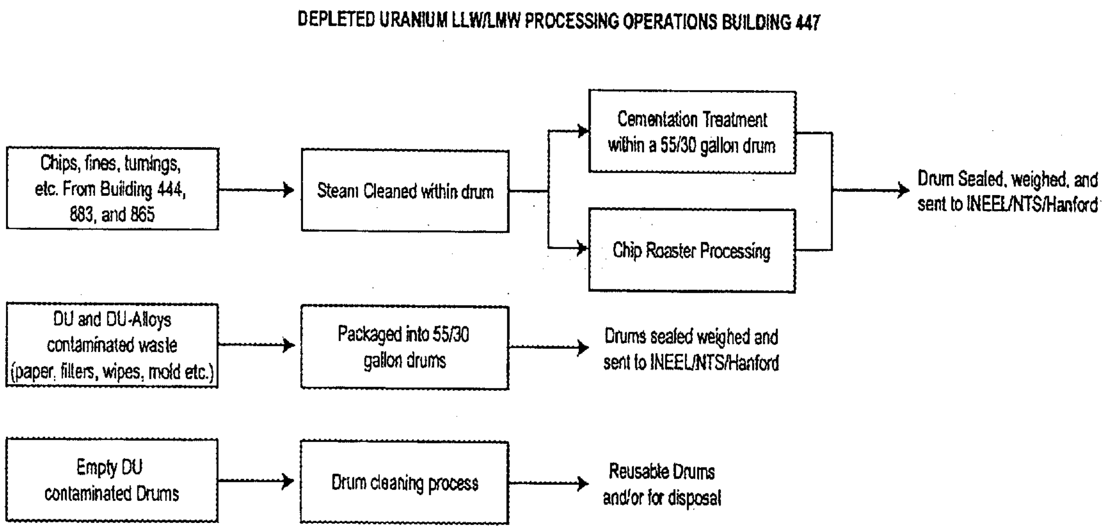


Figure 8.

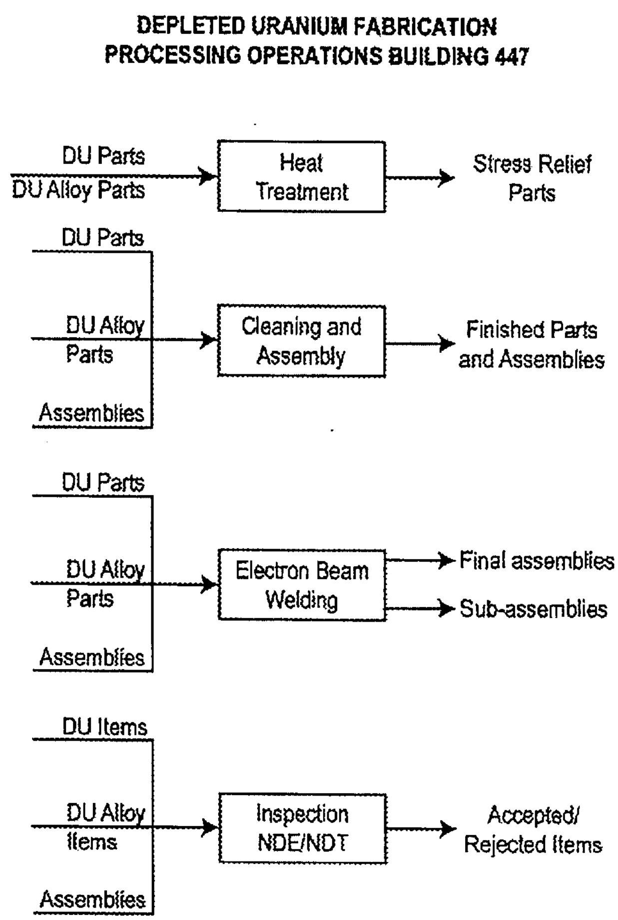


Figure 9.

2.2.4.3 Production Operations

The following is a listing of the processes, operations, and feed materials pertaining to Building 447. Also included is a listing of the waste generated by Building 447.

- Production Operations
  - Vacuum Arc Melting
  - Heat Treating
  - Cleaning (aqueous and chlorinated solvents)
  - Welding (electron-beam, and tungsten-inert-gas)
  - Tensile Testing

- Feed Materials

  - Production Materials
    -- Finished Parts to be Final Cleaned
    -- DU and Niobium Strips for Arc Melting Operation
    -- Component Parts to be Welded
    -- Semi-finished Parts to be Heat Treated

  - Waste Operations
    -- Machining Turnings, Chips, Fines for Chip Roaster
    -- DU/Beryllium Chips for Cementation (for waste disposal)

- Products
  - DU and DU Alloy Products for WR Applications
  - DU and DU Alloy Parts for Special Projects

- Waste Material
  - Roaster Oxides
  - Cemented DU and DU Alloy Chips, Turnings, and Fines
  - Low Level Waste Contaminated with DU (Paper, Wipes, Cloth Items, etc.)
  - Machine Filters
  - Spent Cleaning Solutions
  - Miscellaneous Low Level Contaminated Materials (paper, wipes, rags, floor sweepings, etc.)
    --Filters
    --Spent Graphite Crucibles
    --Spent Lathe Coolant

2.2.4.4 Feed Specifications

The specifications applicable to the DU materials received in Building 447 concerned purity and mechanical properties. There were no requirements pertaining to transuranic constituents and none were performed

2.2.4.5 Product Specifications

Specifications applicable to Building 447 products were final product specifications. These specifications generally concerned purity and mechanical property characteristics. There were no requirements pertaining to transuranic constituents and none were performed

2.2.4.6 Operating History

Building 447 began operations in 1956 for the purpose of supporting Building 444 manufacturing operations. The primary activities included production operations (vacuum arc melting of DU alloys, final cleaning, and non-destructive testing) and waste operations (conversion of DU materials to oxide in the chip roaster, cementation of machine turnings, and off-site shipment of waste materials). Production operations were terminated in 1989.

2.2.4.7 Current Status

Off-site shipment of waste materials continue in support of Building 444 D&D.

2.2.5 Building 865

2.2.5.1 Building Description

Building 865 is a single story facility with a high-bay area that housed the production and development equipment. The building was primarily used for supporting production and for research and development of metal working operations[13] from 1970 to 1994. The southwest corner and northern portions of the building were used for office and laboratory space.

2.2.5. Process Flow

Process flow is not applicable to Building 865. The manufacturing operations that were performed were limited to individual operations, i.e., materials entered the building for specific operations such as swaging, hydo-spinning, and extruding. They were shipped out without additional operations. Research and development operations were performed similarly.

3.0 URANIUM MASS BALANCE

3.1 Uranium Description

The receipt and shipping data for the Site were obtained in separate data bases for both HEU and DU. All uranium receipts and shipments were recorded in electronic data bases